The effect of introducing a Research Evaluation Exercise on student enrolment: Evidence from Italy

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Abstract

This paper examines the impact of introducing a Research Evaluation Exercise (REE) on Italian undergraduate students' enrolment choices. We investigate whether subject-groups in higher education institutions (HEIs) that performed better in the REE also benefited from more student enrolments and the enrolment of students with better entry qualifications. To this aim, we use a before-after estimator that exploits differential treatment intensities across HEIs and subject groups. Our analysis demonstrates that the REE had a positive effect on student enrolment, but only in the top-performing HEIs. The effect was larger for high-quality students, namely those with better high school final marks or coming from the academic track. Further exploratory analysis suggests that there was a reversal in the effect with the second REE, with only medium- or bottom-performing HEIs gaining more enrolments as a result of improving their performance.

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1 Introduction

Several scholars, particularly in the USA, have investigated the effects of ratings and rankings of higher education institutions (HEIs hereafter) produced by private intermediaries (e.g. the *US News & World Report College Rankings*) on student applications and matriculation decisions. These studies have found that the improvement of institutional rankings has a positive effect on student applications (see the literature review in Tutterow and Evans, 2016), however, the size of the effect is not very large and is generally smaller in studies using time-series that control for prior rank (Sauder and Lancaster, 2006). The effect of rankings on the number of applications and matriculations is greater for top institutions (Bowman and Bastedo, 2009), and the way information is presented also matters. A better performance in the league tables is more effective at increasing applications when HEIs are listed by rank rather than in alphabetical order, although this effect is smaller for top institutions, which already have well-established reputations (Luca and Jonathan, 2013). A higher rank is also associated with greater selectivity in admissions, lower acceptance rates (Monks and Ehrenberg, 1999; Meredith, 2004) and higher student quality (Monks and Ehrenberg, 1999; Griffith and Rask, 2007).[1] Evidence also exists for the UK, where researchers have assessed the responsiveness of applications to the rankings produced by popular newspapers such as *The Guardian* or *The Times*. The results are aligned with the US literature. Papers that pool all subjects and analyse the effect of ranking on applications at the university level rather than at the subject-group (i.e. study-field) level generally find smaller effects (Soo, 2013; Broecke, 2015). This is partly because the quality of subject groups varies considerably within an institution (Chevalier and Jia, 2016; Gibbons et al., 2015). Interestingly, UK studies also confirm that the salience of information matters. Information on student satisfaction affects applications only when it is incorporated in league tables, and ranking scores are more relevant when there is a high level of competition among departments and institutions (Gibbons et al., 2015).

Despite abundant evidence on the effects of league tables, none of the studies just mentioned have looked into the effect of "official" rankings, e.g. those produced by government-run Research Evaluation Exercises (REEs), on student choices. On this issue, the evidence is (to the best of our knowledge) almost non-existent. However, given the amount of money often involved in these evaluations, it is important to investigate their effects on stakeholders such as students and their families. We are only aware of two papers investigating the effects of REEs on student choices, both of which provide evidence on the Excellence Initiative run by the German government in 2006 and 2007. This nationwide competition awarded extra funding to the universities with the best future concept for re-

[1] However, Meredith (2004) does not find an effect on the SAT score of applicants.

search. In the first study, using administrative data on student applications, Horstschräer (2012) demonstrates that medical schools in universities that were awarded a status of excellence experienced a significant increase in their number of applications. In the second study, Fischer and Kampkötter (2017) used survey data to show that winning the competition allowed universities to enrol high-school graduates of a significantly higher calibre (in terms of GPA) in three subsequent admission terms. The label of "Excellence University" improved students' ratings of a university's educational quality and their labour market expectations immediately after the award. However, these expectations quickly returned to the baseline level after three years, despite the persistence of the universities' status of excellence.

The evaluation of the research conducted in 2001-2003, (*Valutazione Triennale della Ricerca* 2001-2003, VTR hereafter), which was completed in 2006 and the results of which were made public that same year, represented the first adoption of an official REE in Italy. Like subsequent REEs,[2] it attracted considerable attention from researchers (Rebora and Turri, 2013; Geuna and Piolatto, 2016). However, following a well-established stream of research (see, among others, Jiménez-Contreras et al., 2003; Auranen and Nieminen, 2010), only the effect of the VTR on the supply side of higher education, namely on universities' research productivity, has been assessed (Cattaneo et al., 2016).

Surprisingly, and to the best of our knowledge, there are no studies of the effect of the VTR on the demand side, i.e. on students. In the current paper, we aim to fill this gap by investigating whether the results obtained in the REE had any consequences for Italian HEIs in terms of the number and quality of enrolled students.[3] Two major differences between the Italian VTR and the German Excellence Initiative, which has been already investigated in the literature, are (i) the absence of an overall university ranking in the latter (a status of excellence was awarded to the universities that won the competition, without the possibility of differentiating between non-winning HEIs in terms of quality), which makes it different from REEs; (ii) excellence status was awarded to universities and

[2] The results of the second REE, covering scientific production in the period 2004-2010, (*Valutazione della Qualità della Ricerca*, VQR 2004-2010), were publicly released in 2013, and those of the third REE (VQR 2011-2014) in 2017.

[3] The results of the VTR have already been used in some individual-level studies of Italian students' geographical mobility and labour market outcomes. Ciriaci (2014), using cross-section data, reports that the probability of a student *graduating* from a university outside his or her region of residence increases with the VTR score of the university of destination and decreases as the average score of the universities in their region of residence increases. We add to that paper by providing evidence from panel data, which allows us to deal with university time-invariant or very persistent unobserved heterogeneity (e.g. university reputation) and by providing evidence on student enrolment instead of graduation. Sylos Labini and Zinovyeva (2011) demonstrates that research quality, measured by the VTR score, raises the probability that an individual enrols in a PhD course.

not to HEI subject groups.

Italy is an interesting case study. Italy has always been characterised by the so-called *legal value* of university degrees. This grants formal equality among all degrees irrespective of the awarding institution (e.g. in access to public sector jobs). However, a progressive reduction in public funding for universities,[4] together with a decrease in student numbers,[5] has spurred increasing competition among HEIs, creating a quasi-market for education (on the concept of the quasi-market see, for instance, Niklasson, 1996). In the absence of an official quality assessment of HEIs, students had little guidance when selecting an institution at which to enrol. Popular newspapers such as *La Repubblica* or *Il Sole 24 Ore* have exploited this lack of information by producing specialised publications containing HEI league tables. On the one hand, in this context, the implementation of an official REE by the Ministry of Education, Universities and Research (*Ministero dell'Istruzione, dell'Universit e della Ricerca*, MIUR) is likely to have made a reliable source of information available to students and may have had an impact on their choices. On the other hand, as the object of the evaluation was only research, it is not at all obvious that such information was deemed relevant by students when choosing HEIs. The main goal of this paper is to assess whether or not this was the case.

We provide a first assessment of the impact of the VTR on student choices using a before-after estimator that exploits differential treatment intensities across HEIs. The score obtained in the VTR is the "dose" of the treatment administered to HEIs. In our analysis, we compare HEI outcomes (total enrolments and student quality) before and after the VTR, and look at whether there were significant changes associated with the results obtained in the VTR. The main identification assumption is that there are no omitted contextual variables that may be responsible for these changes. Such unobservable factors must have two features in order to threaten our identification strategy: (1) they must have the same timing as the release of the VTR results; and (2) they must be correlated with the VTR outcomes. This makes clear the importance of exploiting differences in VTR outcomes (i.e. treatment intensities) between HEIs and subject groups for identification purposes. When making a simple before-after comparison, i.e. simply comparing outcomes between the pre- and post-VTR periods, the effect of the VTR may be confounded, for instance, with that of the recession that began in 2008 or with other reforms that were introduced in 2006 (e.g. the extending of compulsory schooling to age 16, mandated by Law no. 296 of 27 December 2006, or the change in the composition of the members of the

[4] The *Fondo di Finanziamento Ordinario* (FFO), which is the main source of public funding for Italian HEIs, decreased from almost 7.5 billion euros in 2009 to less than 6.4 billion euros in 2015.

[5] The total number of students enrolled decreased from a peak of 338,000 in the 2003/2004 academic year (following the "Bologna reform" of 2001) to 255,000 in 2014/2015.

evaluation committee of the upper secondary school final exam, mandated by Law no. 1 of 11 January 2007). By also exploiting *differences in treatment intensities* across HEIs and scientific areas for identification purposes, we are able to control for year-specific or even province-year-specific fixed effects, absorbing *inter-alia*, the impact of the recession and of other reforms that impacted all HEIs similarly. Our identification strategy also enables us to control for time-invariant subject group by HEI heterogeneity (through subject-group HEI fixed effects), which may simultaneously affect the VTR results and the number of enrolments. In some specifications, we also control for subject-group-HEI trends, which might pre-date the implementation of the VTR.

This paper contributes to the extant literature in at least two ways. First, as previously mentioned, our study is the first to systematically examine the effect of an official REE on student decisions. Unlike the previous literature on privately produced league tables, we compare a period in which an official REE was not in place with a period in which an REE was implemented. Thus, unlike the extant research, our paper is not concerned with the effects of increasing HEI rankings but rather, with how HEI enrolments changed over time as a consequence of having performed well (or badly) in the first REE. In this sense, our estimates can be roughly interpreted as the effect of establishing an REE on student enrolment decisions. This is of interest not only to stakeholders in Italy, but also to readers and policy makers in countries that are considering implementing similar REEs. Second, in line with the most recent literature (Chevalier and Jia, 2016; Gibbons et al., 2015), we frame the analysis at the level of subject groups within HEIs. This is important because, similar to newspaper league table rankings, REE rankings are also very likely to differ across disciplines. We show that this is the case for the VTR evaluation exercise, in which there were often considerable differences in the scores of subject groups in the same university.[6] Thus, aggregating the analysis at the HEI level is likely to wash out most of the variation across subject groups and hide the true effect of the research quality assessment on student choices.

The paper proceeds as follows. Section 2 describes the context in which the first Italian REE was introduced, as well as its main characteristics. In Section 3, we explain our empirical strategy. Section 4 describes the data used in the empirical analysis, the results of which are commented on in Section 5. A brief discussion of the main mechanisms through which the VTR could have affected student choices is presented in Section 6. Section 7 reports exploratory analyses for a more recent REE and for other student outcomes. Finally, Section 8 summarises the main findings and offers some concluding remarks.

[6] It is important to note here that within the same *alma mater*, researchers in different subject groups can be affiliated with the same department, and researchers in the same subject groups can be affiliated to different departments.

2 The Italian higher education system and the first Research Evaluation Exercise

2.1 Institutional setup

The Italian higher education system has always been characterised by a high degree of centralisation. Law no. 382 of 11 July 1980 provided that any changes to the existing university supply had to be included in a development plan to be approved by the Minister of Education every three years. Moreover, the opening of new universities required a specific law to be passed by Parliament. University degrees had to meet criteria fixed centrally by the Ministry of Education, concerning, among other things, the curriculum content. The fact that the system was (and still is) almost entirely public and directly managed by the central government, together with the similarity of the degrees supplied by different HEIs, led to the legal recognition of degrees in the same field as identical (*valore legale*, legal value).

On the demand side, until a few decades ago, the student body used to come almost exclusively from families in relatively high socio-economic brackets. Indeed, intergenerational mobility in education has historically been lower in Italy than in other developed countries. For example, Checchi et al. (1999) report that less than 2% of people whose fathers did not complete compulsory schooling end up having a college degree in Italy, while the corresponding figure for the USA is 12%. The evolution from an elite to a mass university system began in 1969, when access to university was liberalised and enrolment in any field became possible for students holding all types of upper secondary school degrees (Law no. 910 of 11 December 1969).[7]

On the supply side, the increased demand for higher education led to the foundation of many new HEIs, faculties and local branches. Reforms between the late 1980s and the early 1990s granted an unprecedented level of autonomy to universities regarding the management of teaching and financial resources. The requirement for parliamentary approval was abandoned in 1990 (Law no. 341 of 19 December 1990), although the requirement of inclusion in a university development plan was retained. However, universities gained the autonomy to advance proposals for new initiatives to the Ministry. Many institutions used this new autonomy to open branches in smaller cities and to increase the number of degrees offered (Bratti et al., 2008; Oppedisano, 2011).

A major step towards a mass tertiary education system was taken with the completion of the Bologna Process and the so-called "3+2" reform (Ministerial Decree no. 509/99).[8]

[7] Before this law, only individuals graduating from a specific upper secondary school academic track (*liceo classico*, i.e. classical lyceum) could enrol in all types of tertiary education.

[8] For a brief description of the "3+2" university reform, see Di Pietro and Cutillo (2008) and Cappellari

The old, long (mostly four- or five-year) degrees were replaced with two levels of degrees: three-year first-level degrees and two-year second-level degrees.[9] The large increase in the supply of degrees offered made it difficult for high school graduates to choose the best possible option according to their preferences and constraints. This made prospective students increasingly interested in knowing the relative quality of institutions and degrees. Also for this reason, about 15 years ago, two of the main Italian newspapers (*Il Sole 24 Ore* and *La Repubblica*) began publishing yearly rankings of Italian universities and faculties.[10]

2.2 The first Research Evaluation Exercise

With the purpose of evaluating the quality of universities and other research institutions receiving public funds and to diffuse this information among stakeholders, the Steering Committee for Research Evaluation (*Comitato di Indirizzo per la Valutazione della Ricerca*, CIVR) initiated the first REE (i.e. the VTR) in December 2003. The REE assessed the research produced by 102 Italian institutions (77 universities and 25 research agencies) for the period 2001-2003. The products evaluated were divided into 20 disciplinary areas: the 14 National University Council (*Consiglio Universitario Nazionale*, CUN) areas plus 6 interdisciplinary sectors.[11] Each university was required to send one product (of its own choosing) per every four researchers, while research agencies were required to submit one product per every two researchers. The first REE was entirely based on a peer review process. A total of 17,329 products were evaluated by 6,661 experts (Franceschet and Costantini, 2011). Each product evaluation, conducted by at least two referees, led to four possible outcomes: excellent, good, passable and of limited value. Furthermore, universities shared data on human resources, international mobility and research funding, in order for the assessment to be as complete and informed as possible. The total cost of the REE was around 3.55 million euros. Initially, only very limited funding was linked to the results of the REE (see, for details Rebora and Turri, 2013).

The final results of the evaluation were released in February 2006, potentially affecting university enrolments beginning in the 2006-2007 academic year. The final VTR ranking score was built as a weighted average, with the number of "excellent" (E) products multiplied by 1, "good" (G) products by 0.8, "passable" (P) products by 0.6 and "limited value"

and Lucifora (2009).

[9] Other courses were also introduced, such as first-level masters degrees and second-level masters degrees, but most students enrolled in the first two types of degrees.

[10] Faculties are the equivalent of schools in the international context.

[11] The CUN's members are elected to advise MIUR on matters related to HEIs.

(L) products by 0.2. The formula is:

$$\text{final VTR score} = \frac{1 \cdot E + 0.8 \cdot G + 0.6 \cdot P + 0.2 \cdot L}{\text{total products evaluated}}. \quad (1)$$

This indicator can vary between 0.2 (if all products are judged as of "limited value") and 1 (if all products are "excellent"). For the purposes of the current study, we use two main indicators of quality. The first is the final VTR score, computed as described above, and the second is the percentage of excellent products (i.e. those evaluated as "excellent"). To make the results of the estimated regressions easier to read, both indicators are included in the econometric models as standardised variables with zero mean and unit standard deviation (σ hereafter), so that their coefficients correspond to the percentage increase (as the dependent variable is measured as a logarithm) in the dependent variable produced by a 1σ increase in the indicator.[12]

3 Empirical strategy

We are primarily interested in the impact of the VTR on the number of university enrolments and the quality of students. We use two measures of student quality. The first is the number of students coming from the upper secondary school academic track (*liceo*), and the second is the number of students with grades above 90 in the upper secondary school final examination (grades range from 60 to 100).[13] We use data on enrolments from 2002 to 2011, that is, before the second and third REEs began. We base our identification strategy on a before-after estimator with differential treatment intensities.[14] The main idea is to look at whether subject-group HEIs (e.g. Economics at the University of Milan) that performed well in the evaluation exercise attracted a larger number of students and a higher calibre of students after the VTR than they did in the past, as compared to subject-group HEIs that did not perform satisfactorily in the research assessment. Our empirical specification is described by the following equation:

[12] The final VTR score for research quality has been used by MIUR to build official rankings of universities in each of the 20 disciplinary areas. Here, we focus on the VTR score and not on the official rankings, as the latter were produced based on university size (large, medium, small). Such a classification is not particularly useful for students who are interested in enrolling in high-quality HEIs, although it may be important for the Ministry, which has to allocate public resources.

[13] Italy has a tracked upper secondary school system. Schools can be divided into three main tracks. The first is represented by the academic track, and we will refer to these schools as the academic high schools. The second is the technical track and the third, the vocational track. Students who choose the academic track generally go on to tertiary education.

[14] Since all HEIs were subject to the VTR exactly at the same time, it is not possible to use a difference-in-differences (DID) strategy (see, for instance, Duflo, 2001).

$$\ln Y_{ijt} = \alpha_0 + \sum_i \alpha_{1i} D_i + \sum_j \sum_t \alpha_{2jt} D_{jt} + \alpha_3 (VTR_i \cdot POST_{2005}) + \epsilon_{ijt} \qquad (2)$$

where i, j and t are subject-group HEI, province and year subscripts, respectively. Y_{ijt} is the number of students enrolled in natural logarithm form. D_i is an indicator variable defined at the subject-group HEI level; D_{jt} are province-year fixed effects;[15] VTR_i a (time-invariant) continuous variable reflecting performance in the VTR and $POST_{2005}$ is a dummy that takes a value of zero before VTR and 1 after. Specifically, the first academic year affected by the reform was 2006/2007, and starting from this academic year, the $POST_{2005}$ indicator takes a value of 1. ϵ_{ijt} is an error term. In this baseline specification, α_3 captures a higher or lower *level* of the outcome variable (e.g. student enrolments or student quality) after 2005 for subject-group HEIs that performed better in the VTR. Subject-group HEI time-invariant factors (e.g. university prestige) are captured by α_{1i} and local factors (e.g. cost of housing, local unemployment, local availability of student residences or scholarships) by α_{2jt}.[16]

The specification in equation (2) controls for subject-group-HEI fixed effects, i.e. subject-group HEIs are allowed to start from different intercepts as far as enrolments and student quality are concerned. These fixed effects control for time-invariant unobserved heterogeneity that might affect the number of enrolments and student quality (e.g. reputation). However, we also estimate a more demanding specification including both subject-group HEI-specific intercepts and subject-group HEI-specific trends, which allow subject-group HEIs to follow different pre-VTR trends in the outcome variables. This may address the concern that subject-group HEIs that saw an increase in enrolment or in student quality after the VTR may have already been on a steeper upward trend before the research assessment. The corresponding specification is:

$$\ln Y_{ijt} = \alpha_0 + \sum_i \alpha_{1i} D_i + \sum_i \gamma_i (D_i \cdot t) + \sum_j \sum_t \alpha_{2jt} D_{jt} + \alpha_3 (VTR_i \cdot POST_{2005}) + \epsilon_{ijt} \quad (3)$$

where the γ_is are the coefficients of the subject-group HEI-specific linear trends $D_i \cdot t$.

[15] In Italy, a province (*provincia*) is an administrative division of intermediate level between a municipality (*comune*) and a region (*regione*). Provinces correspond to Nomenclature of Territorial Units for Statistics 3 (NUTS-3) in Eurostat's classification. Although this is our preferred specification, we also report results including separate province and year fixed effects.

[16] The inclusion of subject-group-HEI and province-year fixed effects implies that the effect of the VTR cannot be identified when a HEI provides courses only in one subject-group in a given province and is the only HEI present in that province. In the dataset, only 49 observations satisfy both of these conditions.

4 Data

Our analysis is based on data from two main sources. Information about the number of students first enrolled in each year and degree course (including a code on the detailed field of study) comes from an old version of the MIUR Statistical Office's website (http://statistica.miur.it).[17] This dataset also includes the number of enrolled students by upper secondary school final grade and track. We focus our analysis on students enrolled in first-level (i.e. undergraduate) degrees. This choice is dictated by the fact that second-level degrees were introduced by universities in the 2004/2005 academic year, meaning there are not enough years before 2006 to estimate the effect of the VTR on student enrolment in these degrees.[18] Student enrolment data for each first-level degree course were aggregated in HEI-province-subject group-year cells, where HEI-province cells define university branches (Italian universities often have branches located in different provinces).

The second data source is a report released by the Steering Committee for Research Evaluation in February 2006. The document contains information on research quality for 77 universities, divided by academic area. We decided to focus our attention on two measures of research quality, the final VTR score and the percentage of excellent products.

Before running the analysis, the two sources of data had to be merged. In the Italian higher education system, first-level and second-level degrees are classified into "degree classes" (*classi di laurea*), i.e. groups that have similar training objectives and a minimum number of credits in given — narrowly defined — subject groups. The latter are defined in terms of scientific sectors (*settori scientifico-disciplinari*). Scientific sectors are subject groups in which academic personnel are placed for career purposes. For instance, researchers can participate in public hiring or promotion competitions only in their (or a

[17] Unfortunately, this website has been taken offline, and data from before 2014 are no longer available. Data on recent academic years are publicly available on the new website http://ustat.miur.it/. All data used in this paper are available upon request.

[18] There are other reasons why it might be preferable to focus on first-level degrees. First of all, while many second-level degrees had a fixed number of slots per year, the same was not true for first-level degrees, where access was unconstrained almost everywhere in Italy in the period under consideration. As we are interested in the effect of research quality on student enrolment, restrictions on the number of slots (for which we do not have data) would be a potential confounding factor in our analysis. We expect that HEIs with a higher score in the REE would tend to rely more on selective admissions for second-level degrees, leading to a potential negative bias in our estimates of the effect on total enrolments. Secondly, the two indicators for the quality of enrolled students used here are likely to be better proxies of student quality prior to starting first-level degrees, whereas for second-level degrees, the final grades of first-level degrees are a better proxy of student ability. Unfortunately, data on the latter are not available. Third, in the first period of implementation, the curricula of second-level degrees were designed to be a natural continuation of the first-level degrees provided by the same institution, and there was little mobility of students across HEIs.

very similar, i.e. "affine") scientific sector.[19] Moreover, a course belonging to a given scientific sector can generally be taught only by academic staff (assistant professors, associate professors or full professors) belonging to the same or to an "affine" sector.

To carry out our analysis, we have to map the results of the VTR, which are available at the level of scientific sector, with student enrolments, which are available at the "degree class" level. We proceed as follows: (1) VTR results are aggregated into broad academic areas according to the National University Council's classification; (2) "degree classes" are aggregated into broad subject groups according to scientific sector; (3) the two sets of subject groups are matched lexicographically. The linking table is reported in Appendix A. We obtained complete information about enrolment and research quality for 518 subject-group HEI groups. We deem this match, which maps the prevailing content of a group of degrees onto the research performance of academic staff in that same subject group, to be sufficiently precise for our purposes.

Figure 1 about here

Figure 2 about here

In Figure 1, we plot the variation in final VTR score between and within institutions. The graph presents the lowest, average and highest scores obtained by each institution. A large majority of universities have quite similar average scores, while there is much larger variation between fields of study within the same institution. To take just one example, the University of Catanzaro obtained a maximum score of 0.87 and a minimum score of 0.2 , with an average score of 0.66. This makes clear the advantage of carrying out the analysis at the subject-group level, since averaging enrolments and REE scores at the HEI level would wash out most of the variation. The relatively low amount of variation in the final VTR score is partly due to the design of the REE, as the number of products sent for evaluation was quite low (one per every four researchers).[20] Figure 2 presents the same information as Figure 1 for the percentage of products that were evaluated as excellent in each subject-group HEI. For this indicator, the variance is larger, with many subject-group HEIs presenting no excellent products and some for which all research output presented was judged as excellent.

By plotting the raw data, figures B1 and B2 in Appendix B visualise the kind of empirical exercise undertaken in this paper. The figures plot the average number of students enrolled per year in subject-group HEIs that obtained low (first quartile) versus high

[19] For instance, a researcher in political economy (*Economia Politica*) can participate in a competition for political economy or economic policy (*Politica Economica*).

[20] This changed in subsequent REEs. Each university research staff member had to submit three research products in the VQR 2004-2010 and two products in the VQR 2011-2014.

(fourth quartile) scores and percentage of excellent products in the VTR. The number of students enrolled per subject-group HEI decreased significantly in both groups during 2002-2011. However, the reduction was larger for subject-group HEIs that received a negative evaluation (i.e. with a score in the first quartile), and a large proportion of the divergence occurred immediately after the publication of the results. Thus, the effect of a better VTR rating on enrolment appears to be positive in the raw data. The falling trend for the whole period is also evident for students graduating from high school with a high mark,[21], whereas for students from academic high schools, the initial decrease in enrolment is compensated for by an increase between 2007 and 2011 for both high and low VTR performing subject-group HEIs.

Sample descriptive statistics for some selected variables are reported in Table 1.

Table 1 about here

5 Results

5.1 Main results on student enrolment

The main results of our analysis are reported in Table 2, which consists of three panels. In each panel, we use a different dependent variable. Panel A uses the number of total enrolments, panel B uses the number of students enrolled who graduated from upper secondary school with a high mark (90 or higher out of 100) and panel C, the number of students enrolled coming from the academic track. In columns 1-3 we focus on the effect of the VTR score and in columns 4-6, on the effect of the percentage of excellent products.

Table 2 about here

The baseline specification in column 1 controls for subject-group-HEI fixed effects and separate province and year fixed effects. Column 1 demonstrates that total enrolments and enrolments of high-mark students are positively associated with VTR score. A 1σ increase in VTR score leads to a 3.7% increase in total enrolments and a 6.2% increase in the enrolment of high-mark students. However, the association between total enrolments and VTR score loses statistical significance when province-year (i.e. interaction) fixed effects are included (column 2), while the coefficient for the enrolment of high-mark students is not affected. All positive associations vanish in column 3, when subject-group-HEI linear

[21] Since students in southern Italy have, on average, higher marks in the high school final examination (see Montanaro, 2008), this trend may simply reflect a more sustained negative trend for HEIs located in the South.

trends are added, suggesting that they may partly be due to different subject-group-HEIs being on different pre-VTR enrolment trends.

The results change markedly when we consider the proportion of excellent products. Our baseline estimates show that a 1σ increase in the proportion of excellent products raises total enrolments and enrolments of high-mark students by 5.8% and 8.7%, respectively. These results are very robust to including province-year fixed effects as well as subject-group-HEI linear trends (columns 5 and 6, respectively). In the most saturated specification in column 6, a 1σ increase in the percentage of excellent products is expected to increase total enrolments by 5.8%, enrolments of high-mark students by 8.3% and enrolments of academic-track students by 12.2%.

To gain an idea of the magnitude of the effects, a 1σ increase in VTR score is equivalent to a 0.1 increase in the score and corresponds to the difference in performance between the economics subject group in Bocconi University, which scored 0.89 in the VTR and ranked in first position (together with the University of Modena and Reggio Emilia), and the same subject group in universities such as Sassari, Siena or Bolzano (see Figure B3 in Appendix B). Similarly, a 1σ increase in the proportion of excellent products is equivalent to a 19 percentage point increase, which roughly corresponds to the difference between the performance of economics at Bocconi University — with 50% of products deemed excellent — and at the University of Bologna (see Figure B4 in Appendix B).

A possible explanation for the difference in results between columns 1-3 and 4-6 is that the effect of the percentage of excellent products is capturing non-linear effects in the VTR score. Indeed, although the two indicators are positively correlated, the correlation tends to be higher for the top performing HEIs in terms of VTR score. This hypothesis is further investigated in Section 5.3.

5.2 Non-parametric specification

Figure 3 about here

A possible concern with our identification strategy is that a high percentage of excellent products in the VTR may pick up time-varying university reputation unrelated to the REE, for which we are not able to control in the regressions. To test this hypothesis, we report the estimates of a less parametric specification in which each pre- and post-VTR year dichotomous indicator is interacted with the proportion of excellent products. This is similar to what is commonly done in event-study analysis or to the strategy of including leads and lags to detect anticipatory effects in difference-in-differences estimates. The interaction with 2002 is omitted and represents the reference group. Ideally, the pre-VTR interactions should be close to zero and statistically insignificant, and the interactions

should be positive and statistically significant only in the post-VTR period if the REE really did have an effect. This is what is observed in coefficients shown in Table C1 in Appendix C, which are plotted in Figure 3. Before 2005, the interactions are never statistically significant and are close to zero. Moreover, the effect is quite constant over time in the post-VTR period, confirming the adequacy of the linear specification in the VTR results of equation (2).[22]

5.3 Non-linear effects

Section 5.1 shows that the percentage of excellent products seems to be much more salient to attracting student enrolments than the VTR score. This is surprising, because the latter was more likely to receive media attention (see our discussion in Section 6).

The Pearson's correlation coefficient between the VTR score and the percentage of excellent products is 0.88 in the fourth quartile of the VTR score and 0.63 in the lower quartiles. In other words, a high percentage of excellent VTR products is a good proxy of VTR score, especially for HEIs with high scores. Thus, we put forward that the difference in the results between the two indicators may actually hide non-linear effects in the VTR score. A similar result is reported in Chevalier and Jia (2016), who find that a better ranking is associated with more applications, and the effect is stronger for institutions in the top quantiles of the quality distribution.

Table 3 about here

Starting from this observation, we estimate a variant of equation (2) in which, in addition to the interaction between VTR score and the post-2005 dichotomous variable, we also add its interaction with a dichotomous variable for being placed in the fourth quartile of the VTR score. In this specification, the non-interacted coefficient captures the effect for the first three quartiles and the interacted coefficient (with Q4), the differential effect for the fourth quartile. The results, reported in Table 3, point to larger effects for HEIs in the top quartile. Focusing on column 3, for instance, VTR score appears to be positively associated with total enrolments only for HEIs in the top quartile (a 13.9% increase for a 1σ increase in VTR score). Similarly, the effect of VTR score on high-mark and academic-track enrolments appears to be strongly positive only for HEIs in the fourth quartile.

[22] In these estimates, subject-group-HEI time trends are omitted because of multicollinearity.

6 Discussion

This section provides a brief discussion of the potential channels through which the VTR might have affected student choices. For new information to have had an impact on students, they must have had access to it. To provide an idea of the diffusion of the VTR results, we searched the historical archive of the Italian newspaper *La Repubblica* for the phrase "Comitato di Indirizzo per la Valutazione della Ricerca" (Steering Committee for Research Evaluation, CIVR), which is the committee that was in charge of managing the VTR. We limited the search to 2006, i.e. the year when the VTR results were released. The search delivered 13 results, 8 of which were related to the VTR (see Table D1 in Appendix D). Apart from one article that comments on the performance of the entire Italian university system in general, all others are focused on specific universities and compare their performance with other HEIs. The press coverage concerns institutions in northern and central Italy (University of Turin, University of Bologna) and southern Italy (University of Palermo, University of Basilicata, University of Naples Federico II). The articles are not limited to good performances in the VTR, but also cover cases of poor performance (e.g. medicine at the University of Palermo). The press coverage of the VTR was therefore fairly good. Even if not all universities were covered by articles in national newspapers, we believe that readers (students and their parents) were made aware of the existence of a national REE and of the university rankings produced by the CIVR, which were publicly and freely available.

Figure D1 in Appendix D depicts the trend in internet searches for the abbreviation "CIVR" in Italy (the term CIVR was mentioned in most press releases). A clear peak in interest coincides with the publication of the VTR results and the appearance of the first articles in the national press (February 2006). The public's interest in the VTR is also demonstrated by the high traffic and the large increase in the number of visits to the website that published the VTR results (`http://vtr2006.cineca.it/`). Figure D2 in Appendix D shows the trend in the number of visits.[23] The website was visited 422,646 times in February 2006, with a monthly average of about 26,000 visits in the rest of the year. Another peak in access is visible in February 2007 (136,025 visits), when the final VTR report was published online. Apart from these two peaks, the amount of visits was fairly constant over time, with a total number of 2,534,948 between January 2006 and December 2011 — a monthly average of 30,178 visits.[24]

[23] The website has been offline since 2015, therefore the access statistics were retrieved from a backup of the website provided by *Internet Archive: Wayback Machine* by running the search query: `https://web.archive.org/web/20120701000000*/http://vtr2006.cineca.it/`.

[24] Although people working in the higher education sector may account for a non-negligible number of visits in February 2006 and February 2007, this is less likely to be the case in other periods. Indeed, the

One possible reading of our results might be that the HEIs that performed well in the VTR made a more intense use of the media to attract students, or that they used some of the funds they received because of their good VTR results to increase advertising. Both actions may be considered as induced by the combination of a good performance in the VTR and higher investment in informational campaigns. In short, they can still be considered as an effect of the VTR. Unfortunately, data regarding the advertising expenditures of HEIs are not available however we conducted an indirect test of this hypothesis using the Italian National Statistical Institute (ISTAT) Survey of Secondary School Graduates (*Indagine sui percorsi di studio e di lavoro dei diplomati*). Specifically, we used the 2007 and 2011 surveys, which refer to secondary school students graduating in 2004 and 2007, respectively. Students who enrolled in higher education before the 2006-2007 academic year are considered untreated, and those enrolled in the 2006-2007 academic year or later are considered as treated by the VTR. In addition to some background information on the students and their families, the survey provides information on the main channels through which students collected information about universities. The possible answers (leaflets and specialised guides, orientation in secondary school, orientation at university, internet, family and friends, the press, other) were recoded to build a dichotomous indicator for having used the internet or the press, i.e. the means that are more likely to be targeted by informational campaigns related to the VTR. If HEIs that performed better in the VTR focused more on advertising, we should observe students being more likely to have used either the internet or the press in universities with a higher VTR score.

We selected the estimation sample in order to include only students who were currently enrolled in a first-level degree or who had already completed a first-level degree and were not currently enrolled in higher education. Thus, we can be sure that the answer to the question above refers to first-level degrees. Moreover, in order to make the two surveys comparable, we dropped from the 2011 survey any student who enrolled in higher education in 2011 (26 students), i.e. four years since their high school graduation, mainly because in the first wave, students were interviewed three years from graduation. The survey provides the *alma mater* and the subject group, to which VTR data can be merged. We estimated linear probability models regressing the probability of having used the press or the internet to collect information about universities on the VTR results, and a set of control variables. In all regressions, we included: student age group at the time of the survey, gender, father's education, mother's education, secondary school region, secondary school track (here we consider more finely defined tracks, namely vocational, technical, academic, pedagogical, artistic), secondary school final mark, year of enrolment in higher education and survey

website was designed solely for the publishing of the VTR results and was not subjected to important updates over time.

year. We then added fixed effects in an incremental way: subject-group fixed effects, subject-group and HEI fixed effects, and subject-group-HEI fixed effects. The sample with non-missing dependent and control variables includes 15,702 observations. Sample descriptive statistics are reported in Table E1 in Appendix E. The estimation results are shown in Table E2 in Appendix E, which includes four columns corresponding to the four sets of fixed effects included. The table shows a statistically significant correlation at the 10% level only in panel A, in the model including subject-group fixed effects (column 1). However, when we compare "like with like", i.e. students enrolled in the same *alma mater* or in the same *alma mater* and subject group before and after the VTR (columns 2 and 3, respectively), the coefficient on the VTR score falls in magnitude and becomes statistically insignificant. Panel B, where an interaction term between the treatment and the top quartile of the VTR score is included, shows similar results. Thus, this indirect test offers no supporting evidence that the increase in the number of student enrolments in the HEIs that performed well in the VTR was mainly driven by an increase in advertising.

One might wonder if the information provided by the VTR was indeed new, or if it simply provided similar information to what was already available to students through rankings produced by newspapers.[25] Although this possibility seems to be excluded by the results of Section 5.2, to further test this hypothesis, we used information from the Censis-Repubblica University Guides, which build rankings at the subject-group level. We gathered a dataset from the paper editions of the annual guides, covering the whole period of our analysis. The guides provide different indicators and rankings, and we focus here on the final score,[26] which was used by Censis-Repubblica to compile the rankings of subject-group HEIs. This indicator is included as an additional covariate in the different models, and the results are reported in Table F1 in Appendix F. The estimates on VTR score and the percentage of excellent products turn out to be very robust to the inclusion of the Censis-Repubblica quality indicator and very close to those reported in Table 2. This suggests that the VTR had an additional effect over and above the league tables already available to the public. The effect of the Censis-Repubblica score is positive and statistically significant in some models, especially in those omitting subject-group-HEI trends.

[25] Pigini and Staffolani (2016), for instance, use a cross-section of Italian secondary school graduates to show that more talented students' enrolment decisions are affected by university quality — proxied by the Censis-Repubblica scores — irrespective of family socio-economic status.

[26] The final score is constructed as the average of standardised scores in four areas: productivity, teaching, research and internationalisation.

7 Additional results

In this section, we provide additional results on other effects of the REEs on students. In particular, in Section 7.1, we extend the analysis to the second REE (VQR 2004-2010).

7.1 Effect of the first and second REEs on student enrolment

Although in our main analysis, we studied the effect of *introducing* an REE on student enrolment decisions, one may also be interested to know the gains in student enrolments that a HEI can achieve by improving its performance in the REEs. We limit the analysis to the first two REEs, i.e. the VTR and the VQR 2004-2010 (VQR1, hereafter), the results of which were publicly released in September 2013. Since results of the latest REE (VQR 2011-2014) were published in January 2017, there is not enough post-REE data to analyse its effects. The estimated equation reads as

$$\ln Y_{ijt} = \beta_0 + \sum\nolimits_i \beta_{1i} D_i + \sum\nolimits_j \sum\nolimits_t \beta_{2jt} D_{jt} + \beta_3 REE_{ijt} + \epsilon_{ijt} \tag{4}$$

where $\ln Y_{ijt}$ is the logarithm of student enrolments, D_i are subject-group-HEI fixed effects and D_{jt} are province-year fixed effects (in some specifications, we use separate province and year fixed effects). REE_{ijt} is the result of either the VTR or the VQR1 in the subject-group-HEI, standardised to have mean zero and standard deviation one. Since the VQR1 results were published in September 2013, the first academic year affected by this REE is 2013/2014. Thus, REE_{ijt} contains the values of the VTR before 2013 and the values of the VQR1 after 2012. Data on student enrolments after 2013 were taken from the new version of MIUR's Statistical Office website and are publicly available.[27] However, the time series starts from the 2014/15 academic year, so we have a break in the data (i.e. the 2012/13 and 2013/14 academic years are missing). Thus, we run the regression (4) on the pooled sample including the academic years of 2006/07-2011/12 (6 years) and 2014/15-2016/17 (3 years).

This specification estimates a different parameter from that identified in Section 3. Indeed, while in Section 3 we focus on the first REE and estimate the effect of *introducing an REE*, in this section, we estimate the effect of *improving a HEI's performance in the REE*. For a number of reasons, we expect these two situations to differ. First, the introduction of an REE probably offers an informational content larger than the simple improvement of performance in the REE, especially when information on university quality is scarce.

[27] http://dati.ustat.miur.it/organization/ace58834-5a0b-40f6-9b0e-ed6c34ea8de0?tags=Universit%C3%A0&tags=Studenti. Data on type of upper secondary school and upper secondary school final exam marks have not been released. The old version of the MIUR Statistical Office's website reported enrolment data only until the 2011/2012 academic year.

Second, and more importantly, there is little that HEIs could have done to improve their performance in the *first* REE because it was based on past research, in a period in which scholars did not expect a REE. By contrast, after the VTR, HEIs began to better understand how the REEs function and adopted policies to improve their performance. Thus, a change in score between the two REEs can hardly be seen as "exogenous".

Table 4 about here

Despite these caveats, the estimation of equation (4) reported in Table 4 can still be informative. Column 1 (panel A) reports the results of the specification including separate province and year fixed effects and subject-group-HEI fixed effects. Interestingly, a 1σ increase in the REE score is associated with a 7.1% rise in student enrolment (statistically significant at the 5% level). The coefficient is smaller when province-year fixed effects are included (column 2, panel A), falling to 4.3% and losing statistical significance.

In panel B, we report the estimates including an interaction term between REE performance and Q4 (i.e. being placed in the fourth quartile of the REE indicator, where the quartiles are REE-specific). Quite interestingly, the results show that HEIs in Q1-Q3 gain more enrolments from improving their performance, compared to the HEIs in the top quartile, for which there is a negative gradient for the REE score. This is an interesting finding that deserves further analysis. If confirmed by the post-VQR 2011-2014 data, this evidence may suggest that research-intensive universities are changing their development strategies, switching from a model of expansion based on increasing student numbers, which was the main method of obtaining new public resources in the past, to a model based on student quality and research excellence, e.g. by increasing selective entry mechanisms at the undergraduate level (i.e. courses with a planned number of students, *numero programmato*). This may have been partly induced by the gradual increase in the share of resources allocated by the government according to REEs. Indeed, Law no. 98 of 9 August 2013 provides for a gradual increase, reaching 30% of total public funding at "full regime", of which 3/5 must be allocated according the most recent REE results. Similar effects of a good performance in rankings on HEI selectivity are indeed observed in other countries (Monks and Ehrenberg, 1999; Meredith, 2004).

8 Concluding remarks

This paper focuses on the first Italian REE (the VTR), which was completed in 2006. It features the first assessment of the VTR's impact on student decisions, namely on the total number of university enrolments and on the enrolment of high-quality students, proxied by high school final examination marks and graduation from the academic high school track.

To the best of our knowledge, our paper also represents the first study investigating the effect of establishing an REE on student enrolment decisions.

We relate the number of student enrolments at the subject-group-HEI level to VTR ratings using a "differential intensity" before-after estimator. In particular, we investigate whether subject-group HEIs with a better VTR performance in 2006 also had better student enrolment outcomes after 2006.

Our analysis for the period 2002-2011 shows that the final VTR score had an effect on the number and quality of students enrolled, but that the effect was differentiated across the score distribution. Indeed, in our preferred specification (including subject-group-HEI and province-year fixed effects), a 1σ increase in VTR score (i.e. 0.1 points on the VTR scale, which ranges from 0.2 to 1) leads to a 13.9% increase in total enrolments, but only for HEIs in the first quartile of the score. In these HEIs, a 1σ increase in VTR score also leads to a 24.4% increase in the enrolment of students graduating from upper secondary school with a high mark (at least 90 out of 100) and a 33% increase in students coming from the academic high school track,. In contrast, an increase in VTR score does not translate into similar gains in enrolment for HEIs in lower quartiles. This last result points to the potentially inequality-enhancing effects of REEs, which might further increase the enrolment gaps between top-ranked and lower-performing HEIs.

The positive effect of the VTR on student enrolment and student quality may be explained by student access to new information about the "quality" of universities, as shown by the high volume of traffic on the website that published the VTR results, especially at the time of the first press coverage of the VTR (February 2006). Investigating potential mechanisms, we find that the increase in student enrolments does not seem to be driven by an increase in advertising activities by HEIs however, and that the VTR appears to have an information content over and above rankings already available to students. Since a similar evaluation of university teaching was not in place during the same period, a possible reading of our results is that, in the absence of reliable information on teaching quality, students were using research performance in the REE as a proxy for teaching quality.

Further exploratory analyses using data from both the first and second REEs (i.e. VTR and VQR 2004-2010) show that there were enrolment gains associated with an improved performance on the REE, but that the top-performing institutions did not benefit from this. Indeed, top-ranked institutions (in terms of research) show a negative enrolment gradient in the REE scores when the analysis focuses on the 2006-2016 period. We put forward that the top research institutions might have increased their level of selectivity, possibly reducing student numbers in an attempt to maintain their focus on research and increase their share of public funding allocated according to research performance in the most recent REEs. Such a hypothesis would deserve further investigation.

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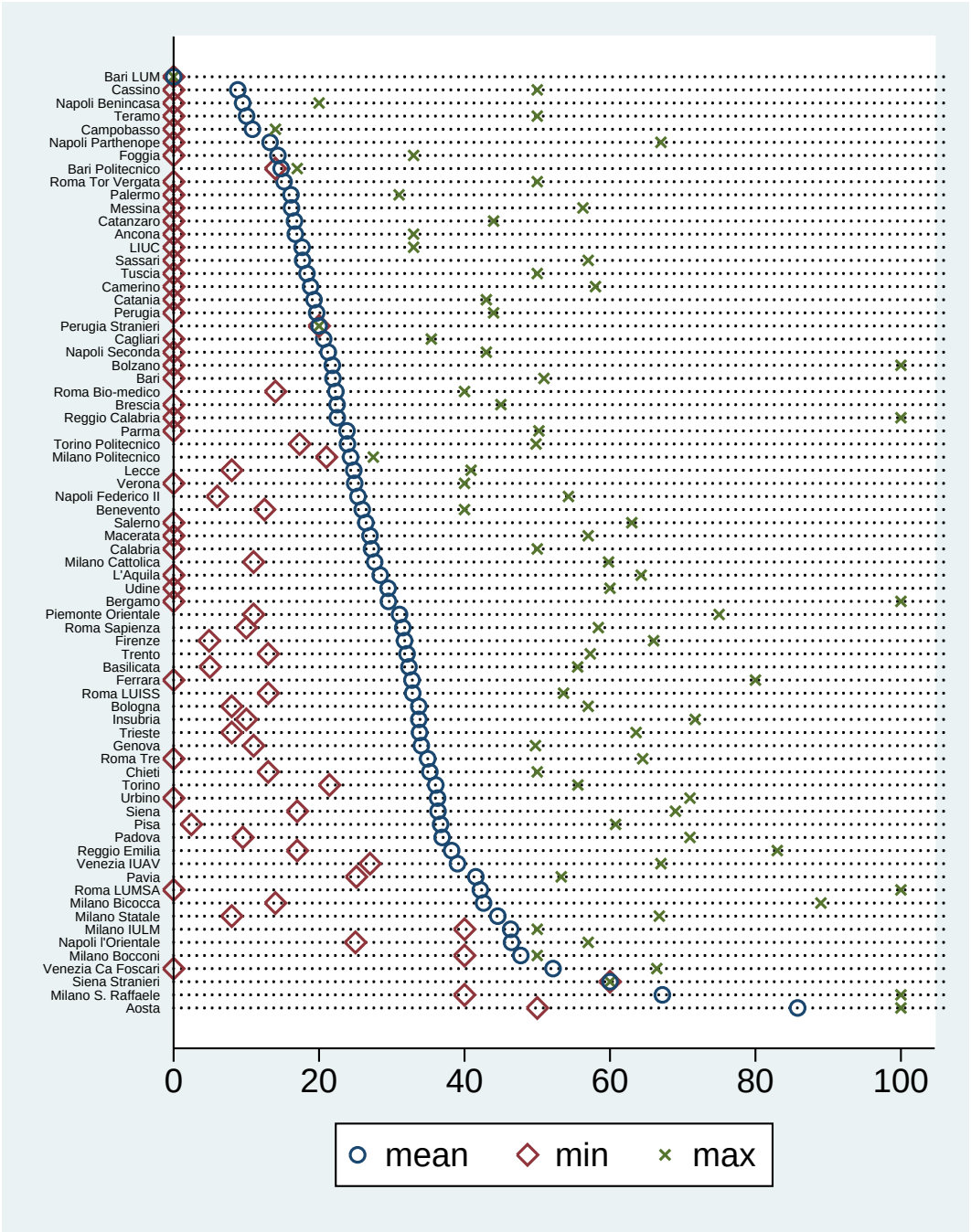
Figure 1: VTR final score by university

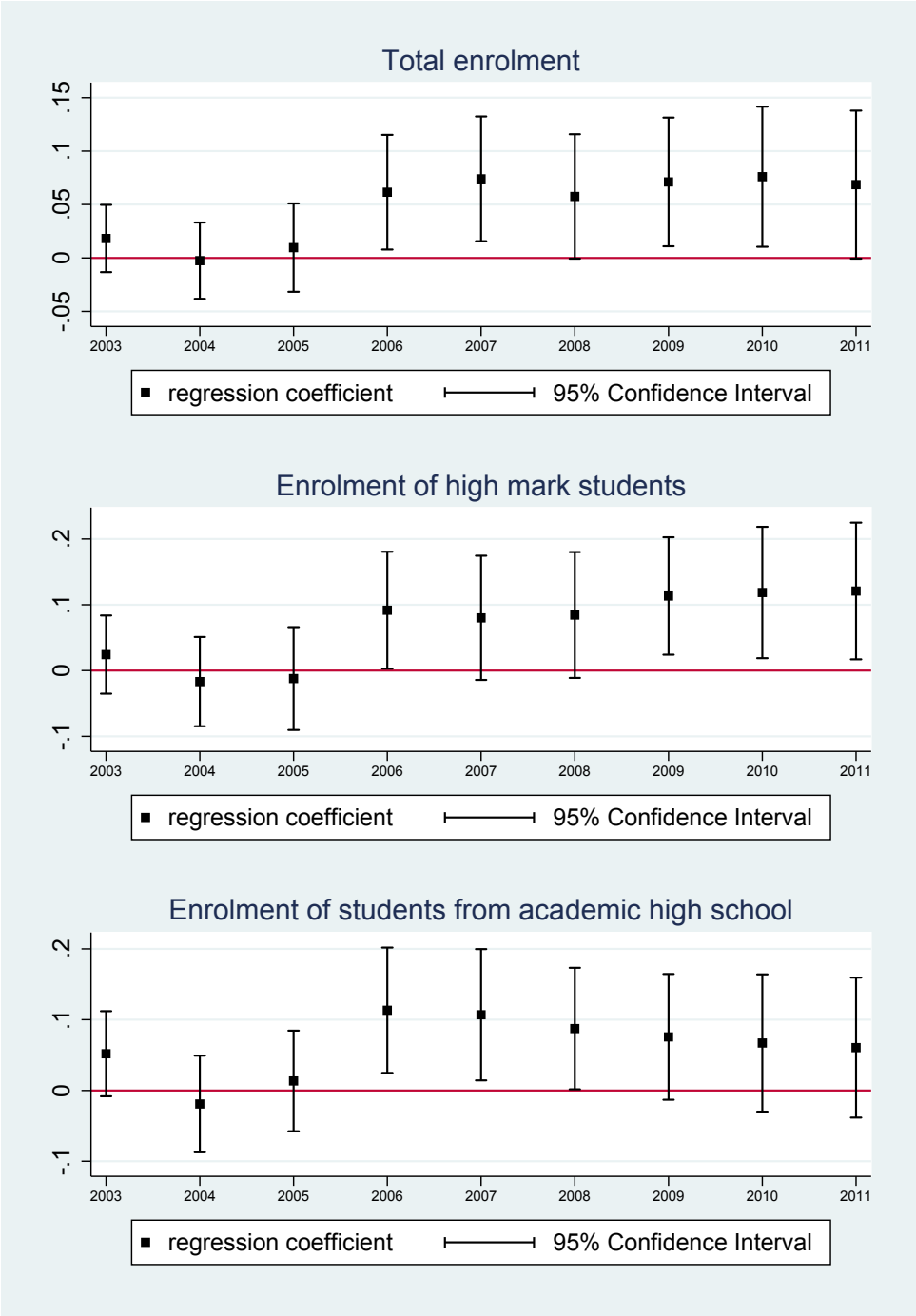
Note. The figure plots the maximum, the minimum and the mean of the VTR score by HEI. Each value refers to a different subject group.

Figure 2: Percentage of excellent VTR products by university



Note. The figure plots the maximum, the minimum and the mean of the percentage of excellent VTR products by HEI. Each value refers to a different subject group.

Figure 3: Coefficients and confidence intervals for the proportion of excellent products interacted with year dummies



Note. This picture shows the coefficients on the interaction terms between proportion of excellent products and year dummies estimated in Table C1. The interaction with 2002 represents the reference group. The first, second and third graphs refer to regressions using total enrolment, enrolment of high-mark students and enrolment of students from academic high school track as dependent variables, respectively.

Table 1: Sample descriptive statistics

Variables	Mean	Std.Dev.
VTR score	0.775	0.103
% excellent products	28.01	18.98
Enrolment		
2002	395.76	512.59
2003	395.95	513.10
2004	377.11	484.67
2005	367.72	470.04
2006	316.90	420.46
2007	318.56	423.11
2008	306.90	408.31
2009	306.63	403.73
2010	308.92	403.76
2011	310.11	414.98

Note. This table reports some descriptive statistics for some selected variables used in our analysis. Enrolments are the average number of undegraduate students enrolled at the subject-group-HEI level.

Table 2: Effect of VTR on total (log) students enrolled

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	VTR score			% Excellent products		
Panel A. Total enrolment						
VTR · $Post_{2005}$	0.037*	0.024	0.014	0.058***	0.062***	0.058**
	(0.020)	(0.024)	(0.024)	(0.022)	(0.024)	(0.023)
Number of observations	7350	7302	7302	7350	7302	7302
R^2	0.822	0.840	0.887	0.822	0.841	0.887
Panel B. High-mark enrolment						
VTR · $Post_{2005}$	0.062**	0.065**	-0.005	0.087***	0.102***	0.083**
	(0.026)	(0.031)	(0.042)	(0.028)	(0.031)	(0.036)
Number of observations	7302	7254	7254	7302	7254	7254
R^2	0.745	0.778	0.835	0.745	0.779	0.835
Panel C. Academic-track enrolment						
VTR · $Post_{2005}$	0.003	0.012	0.030	0.042	0.074**	0.122***
	(0.028)	(0.032)	(0.039)	(0.033)	(0.034)	(0.038)
Number of observations	7302	7254	7254	7302	7254	7254
R^2	0.727	0.801	0.854	0.727	0.801	0.855
control variables (all panels):						
Subject-group-HEI FE	Yes	Yes	Yes	Yes	Yes	Yes
Province and year FE	Yes	No	No	Yes	No	No
Province-year FE	No	Yes	Yes	No	Yes	Yes
Subject-group-HEI linear time trends	No	No	Yes	No	No	Yes

*, **, *** statistically significant at the 10, 5 and 1% levels. Standard errors are clustered at the subject-group-HEI level.

Note. Panel A, B and C refer to models using as dependent variables the logarithm of total undegraduate enrolments, of high-mark enrolments and of academic-track enrolments, respectively. In columns 1-3 the VTR variable listed in the first column ("Variables") is the VTR score and in columns 4-6 is the % of excellent research products. The number of observations differs across panels because some HEIs did not provide data on the number of student enrolments by secondary school final mark and secondary school track. Moreover, the number of observations differs across columns because singleton groups (defined by the combination of fixed effects) are dropped in the estimation. This is done as retaining singletons may overstate statistical significance and lead to incorrect inference (Correia, 2015).

Table 3: Effect of VTR on total (log) students enrolled by quartile of VTR score

Variables	(1)	(2)	(3)
Panel A. Total enrolment			
VTR score · $Post_{2005}$	-0.004	-0.039	-0.034
	(0.025)	(0.030)	(0.031)
VTR score · $Post_{2005}$ · Q4	0.158**	0.230***	0.173**
	(0.069)	(0.077)	(0.074)
Number of observations	7350	7302	7302
R^2	0.823	0.841	0.887
Panel B. High-mark enrolment			
VTR score · $Post_{2005}$	0.018	-0.000	-0.099*
	(0.033)	(0.040)	(0.054)
VTR score · $Post_{2005}$ · Q4	0.169*	0.239**	0.343***
	(0.096)	(0.102)	(0.108)
Number of observations	7302	7254	7254
R^2	0.745	0.779	0.835
Panel C. Academic-track enrolment			
VTR score · $Post_{2005}$	-0.041	-0.065	-0.084*
	(0.036)	(0.041)	(0.050)
VTR score · $Post_{2005}$ · Q4	0.167*	0.284***	0.414***
	(0.098)	(0.106)	(0.111)
Number of observations	7302	7254	7254
R^2	0.727	0.801	0.855
control variables (all panels):			
Subject-group-HEI FE	Yes	Yes	Yes
Province and year FE	Yes	No	No
Province-year FE	No	Yes	Yes
Subject-group-HEI linear time trends	No	No	Yes

*, **, *** statistically significant at the 10, 5 and 1% levels. Standard errors are clustered at the subject-group-HEI level.

Note. Panel A, B and C refer to models using as dependent variables the logarithm of total undegraduate enrolments, of high-mark enrolments and of academic-track enrolments, respectively. Q4 is a dichotomous indicator for the fourth quartile of the VTR score (lower quartiles are the reference group). The number of observations differs across panels because some HEIs did not provide data on the number of student enrolments by secondary school final mark and secondary school track. Moreover, the number of observations differs across columns because singleton groups (defined by the combination of fixed effects) are dropped in the estimation.

Table 4: Effect of VTR and VQR 2004-2010 results on (log) enrolments

Variables	(1)	(2)
Panel A. Baseline		
REE score	0.071**	0.043
	(0.030)	(0.027)
Number of observations	6342	6272
R^2	0.844	0.865
Panel B. With Q4 interaction		
REE score	0.092***	0.066***
	(0.029)	(0.027)
REE score · Q4	-0.127***	-0.137***
	(0.046)	(0.044)
Number of observations	6342	6272
R^2	0.844	0.866
control variables (all panels)		
Subject-group-HEI FE	Yes	Yes
Province FE	Yes	No
Year FE	Yes	No
Province-year FE	No	Yes

*, **, *** statistically significant at the 10, 5 and 1% levels. Standard errors are clustered at the subject-group-HEI level.

Note. The dependent variable is the logarithm of total undegraduate student enrolments. The estimation refers to the pooled 2006-2011 and 2014-2016 periods. REE variables refer to the VTR (results published in 2006) in the subperiod 2006-2011 and to the VQR 2004-2010 (results published in 2013) in the subperiod 2014-2016. Q4 is a dichotomous indicator for the fourth quartile of the REE score (lower quartiles are the reference group). The number of observations differs across columns because singleton groups (defined by the combination of fixed effects) are dropped in the estimation.

Appendix

A Mapping of research to teaching subject groups

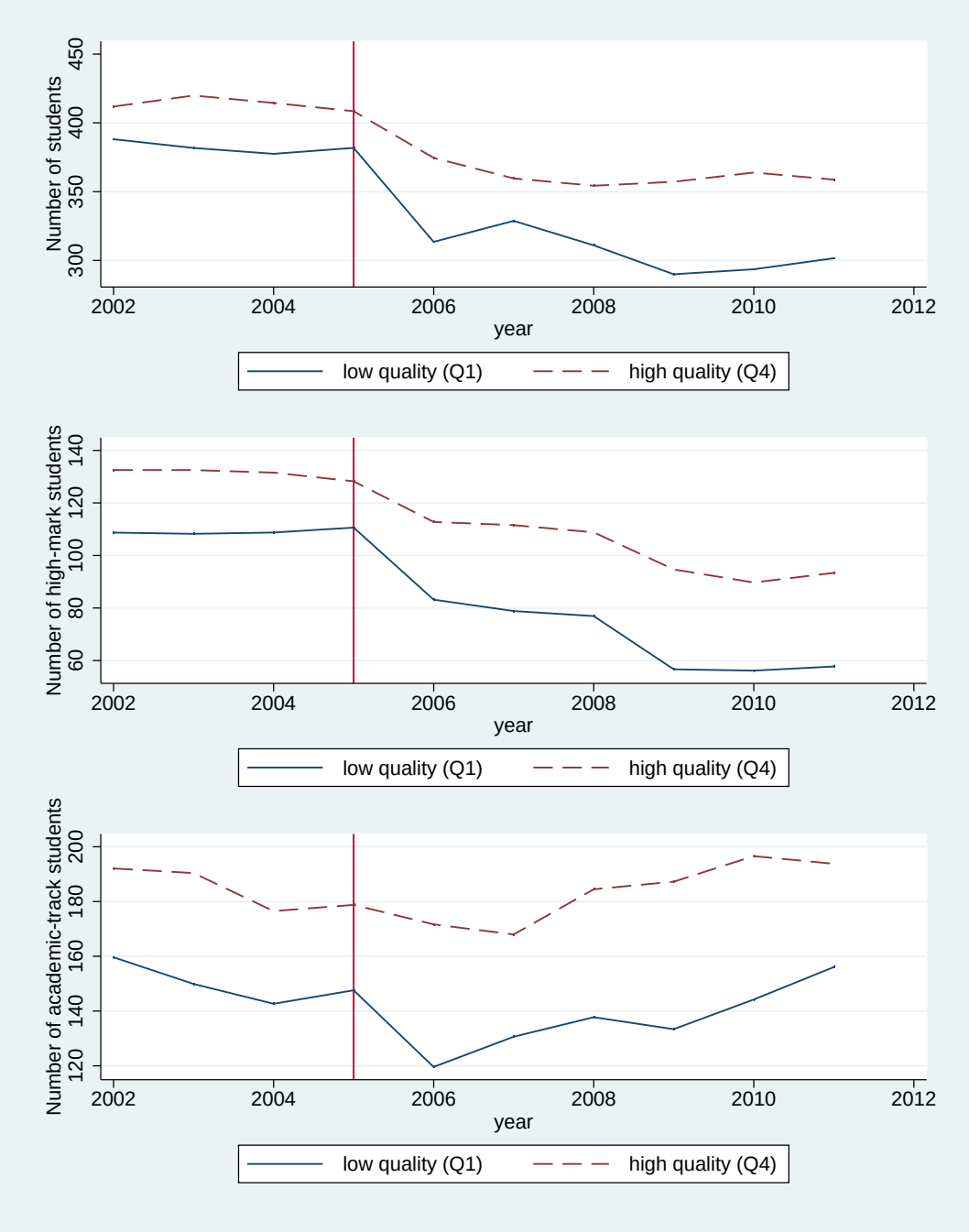
Table A1: Mapping of VTR to teaching subject groups

Identifiers	Disciplinary areas (VTR)	Teaching subject groups
1	1+2	Hard sciences (maths and physics)
2	3	Chemistry
3	4+5+15e	Biology
4	6	Medicine
5	7+15b	Agriculture
6	8	Architecture
7	9+15c+15d	Engineering
8	10+15f	Humanities
9	11	Teaching and psychology
10	12	Law
11	13	Economics and Statistics
12	14+15a	Political and Social sciences

Note. In the first column, we show the identifiers of the 12 areas that we use in the analysis. They result from merging the disciplinary areas in the VTR (second column) and the fields of study as classified by the Ministry of Education, Universities and Research (MIUR) for teaching purposes (third column). The disciplinary areas in the VTR are the 14 CUN areas (1 - Mathematics and Computer Sciences, 2 - Physics, 3 - Chemistry, 4 - Earth Sciences, 5 - Biology, 6 - Medicine, 7 - Agriculture and Veterinary, 8 - Civil Engineering and Architecture, 9 - Industrial and Information Engineering, 10 - Humanities, 11 - Teaching and Psychology, 12 - Law, 13 - Economics and Statistics and 14 - Political and Social Sciences) plus 6 inter-disciplinary areas (15a - Science of information and communication, 15b - Science for food quality and safety, 15c - Science for nano-microsystems, 15d - Aerospace sciences, 15e - Science for sustainable development and governance, and 15f - Science for the evaluation and enhancement of cultural heritage).

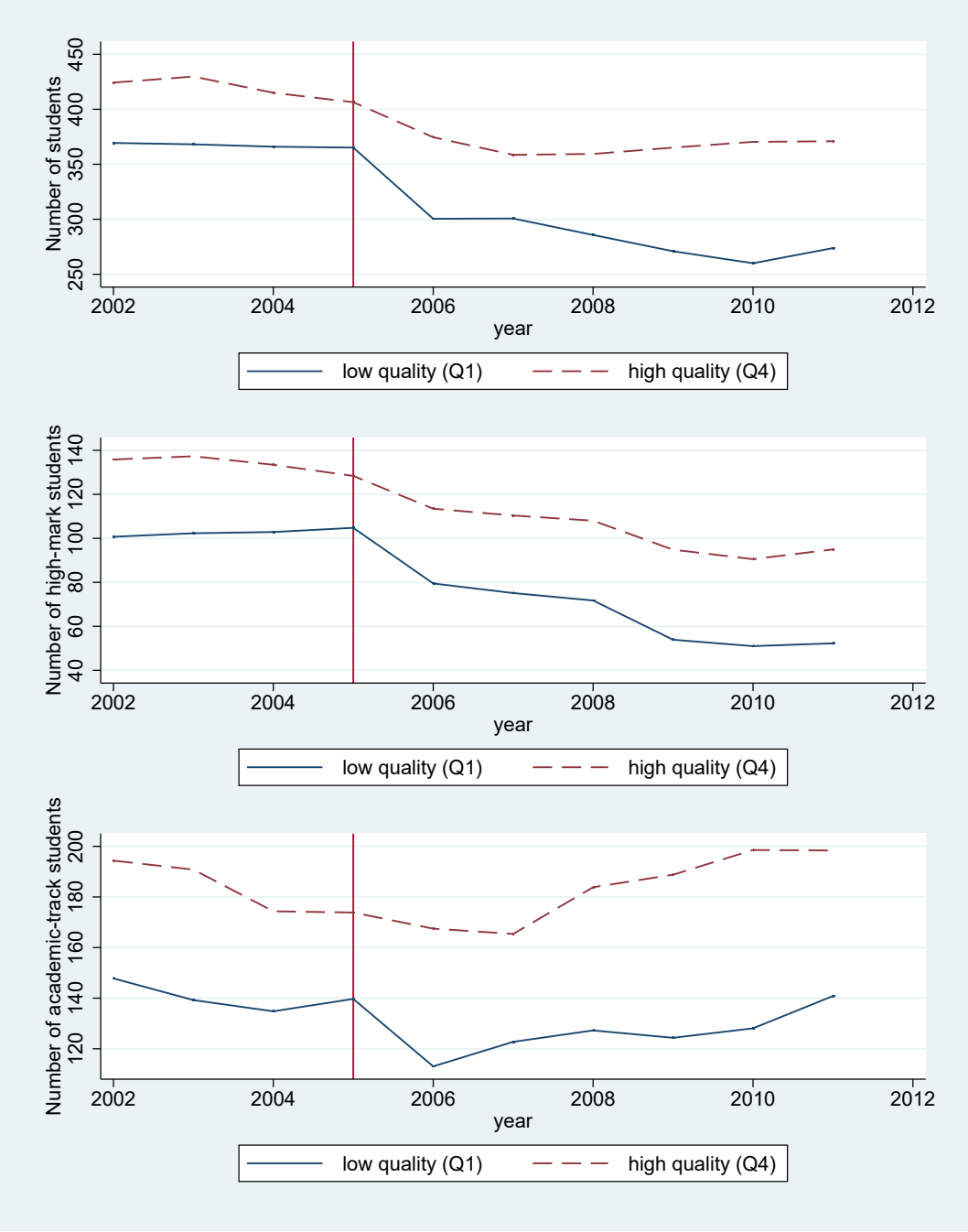
B Additional figures

Figure B1: Average number of students enrolled by year for first (Q1) and fourth (Q4) quartiles of VTR score



Note. The vertical line is drawn for the last academic year (2005/2006) that was not affected by the VTR.

Figure B2: Average number of students enrolled by year for first (Q1) and fourth (Q4) quartiles of % excellent products



Note. The vertical line is drawn for the last academic year (2005/2006) that was not affected by the VTR.

Figure B3: VTR final score for the economics subject group by HEI

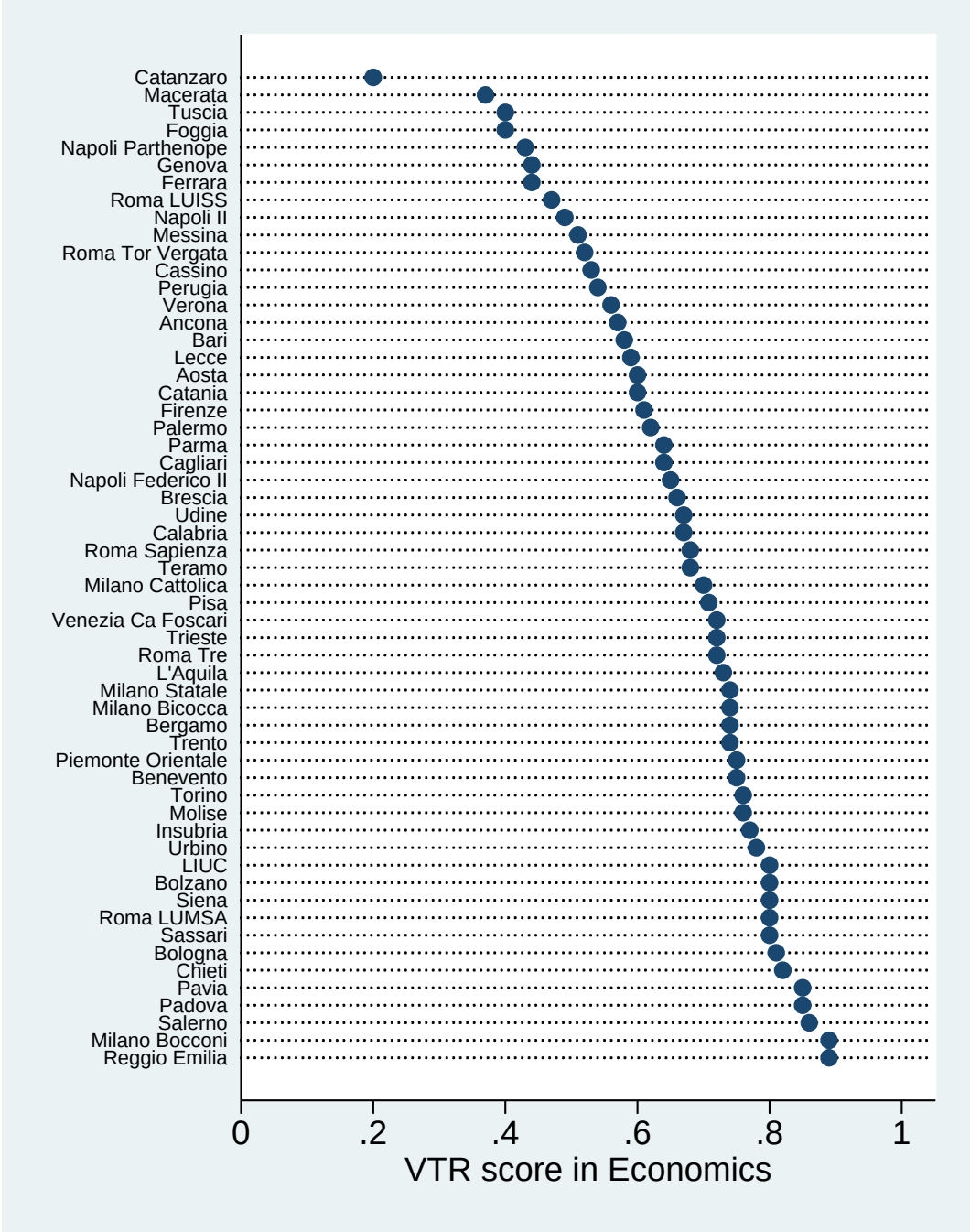
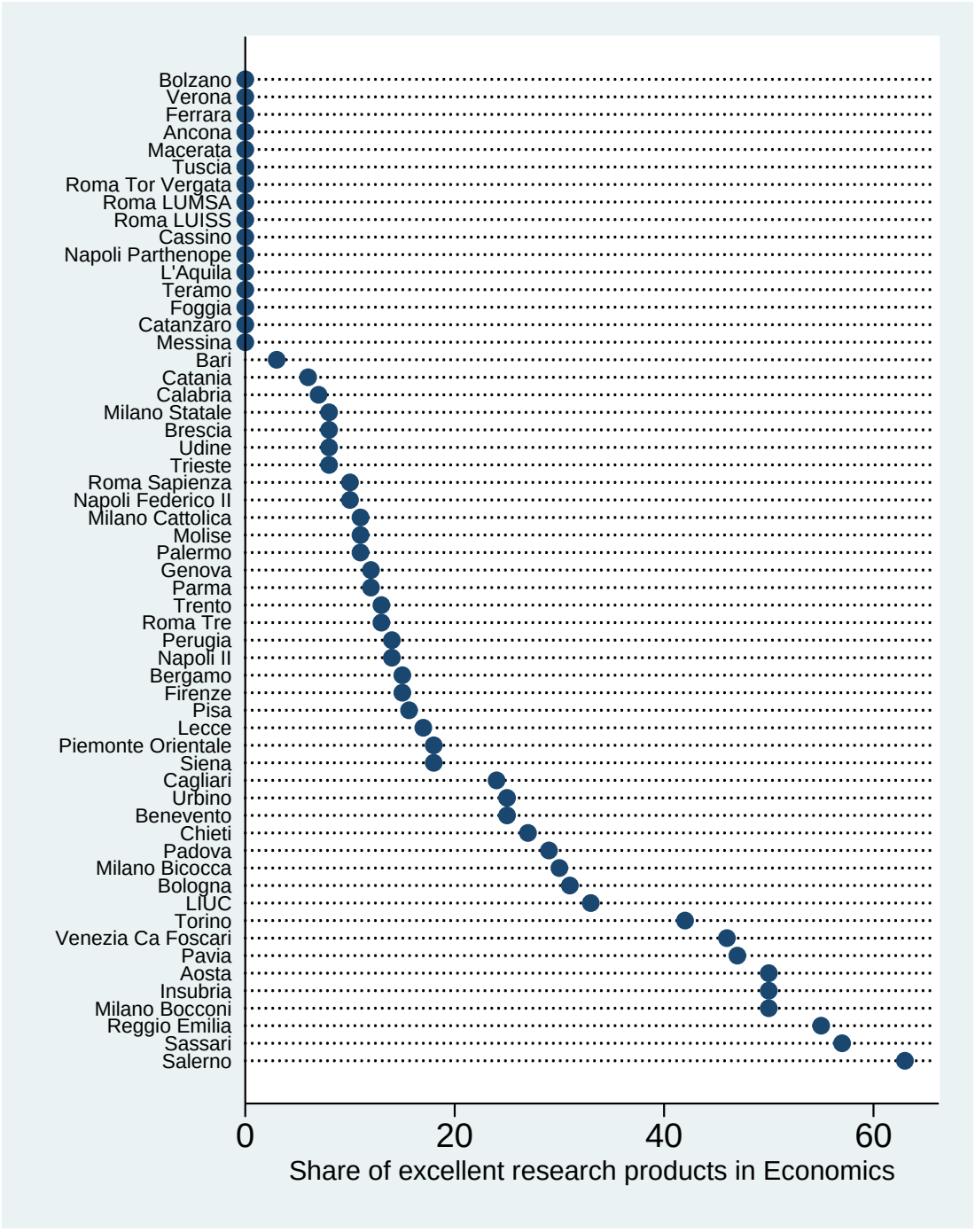


Figure B4: Proportion of excellent products by economics subject-group HEI



C Non-parametric specification

Table C1: Effect of VTR percentage of excellent products on student enrolment outcomes

Variables	Total enrolment	High-mark	Academic-track
	(1)	(2)	(3)
% of VTR excellent products · 2003	0.018	0.024	0.052*
	(0.016)	(0.030)	(0.031)
% of VTR excellent products · 2004	-0.003	-0.017	-0.019
	(0.018)	(0.035)	(0.035)
% of VTR excellent products · 2005	0.010	-0.012	0.013
	(0.021)	(0.040)	(0.036)
% of VTR excellent products · 2006	0.062**	0.092**	0.113**
	(0.027)	(0.045)	(0.045)
% of VTR excellent products · 2007	0.074**	0.080*	0.107**
	(0.030)	(0.048)	(0.047)
% of VTR excellent products · 2008	0.058*	0.084*	0.087**
	(0.030)	(0.049)	(0.044)
% of VTR excellent products · 2009	0.071**	0.113**	0.076*
	(0.031)	(0.045)	(0.045)
% of VTR excellent products · 2010	0.076**	0.119**	0.067
	(0.033)	(0.051)	(0.049)
% of VTR excellent products · 2011	0.069*	0.121**	0.061
	(0.035)	(0.053)	(0.050)
Number of observations	7302	7254	7254
R^2	0.841	0.779	0.801
control variables:			
Subject-group-HEI FE	Yes	Yes	Yes
Province-year FE	Yes	Yes	Yes

*, **, *** statistically significant at the 10, 5 and 1% levels. Standard errors are clustered at the subject-group-HEI level.

Note. Columns 1-3 report coefficients on the percentage of excellent products by year interactions for the three regressions using (log) total undergraduate enrolments, (log) high-mark enrolments and (log) academic-track enrolments, respectively, as dependent variables. The interaction with 2002 is omitted and is the reference group.

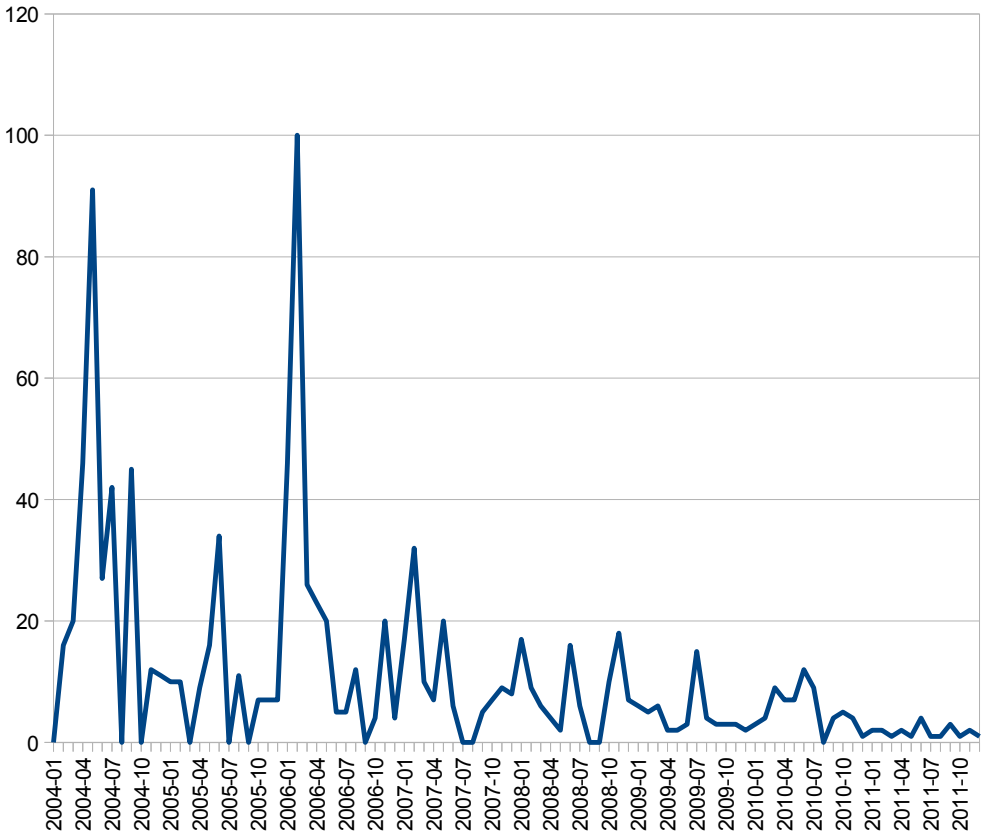
D VTR media coverage

Table D1: Press coverage of VTR in 2006, *La Repubblica* newspaper

Article title	Date	Universities covered	Content
Research? A sector or excellence. Still huge the North-South divide	31 January	Whole university system	General coverage of VTR results
Chemistry, economics and politics the gold research of the university	1 February	University of Bologna	Comparison between University of Bologna and other Italian Universities (also by subject) in VTR performance
Federico II among the "big ones" of research	15 February	Federico II, Naples	Comparison between Federico II and other Italian universities (also by subject) in VTR performance
The Faculty of Medicine last in Italy for research	8 February	University of Palermo	Information of poor performance of the University of Palermo's Faculty of Medicine
The ranking of faculties help us to improve the university	10 February	University of Palermo	General discussion on how to use the VTR to improve universities' performances
Research, university promoted to the first place for biomedicine	17 March	University of Turin	Comparison of University of Turin and other universities in VTR performance
Promoted Guido the innovator but on the Statuto he made a mistake	9 May	Federico II, Naples	Mention of good performance of Federico II in VTR
University of Basilicata	16 June	University of Basilicata	Censis-Repubblica page of the University of Basilicata mentions good position in VTR

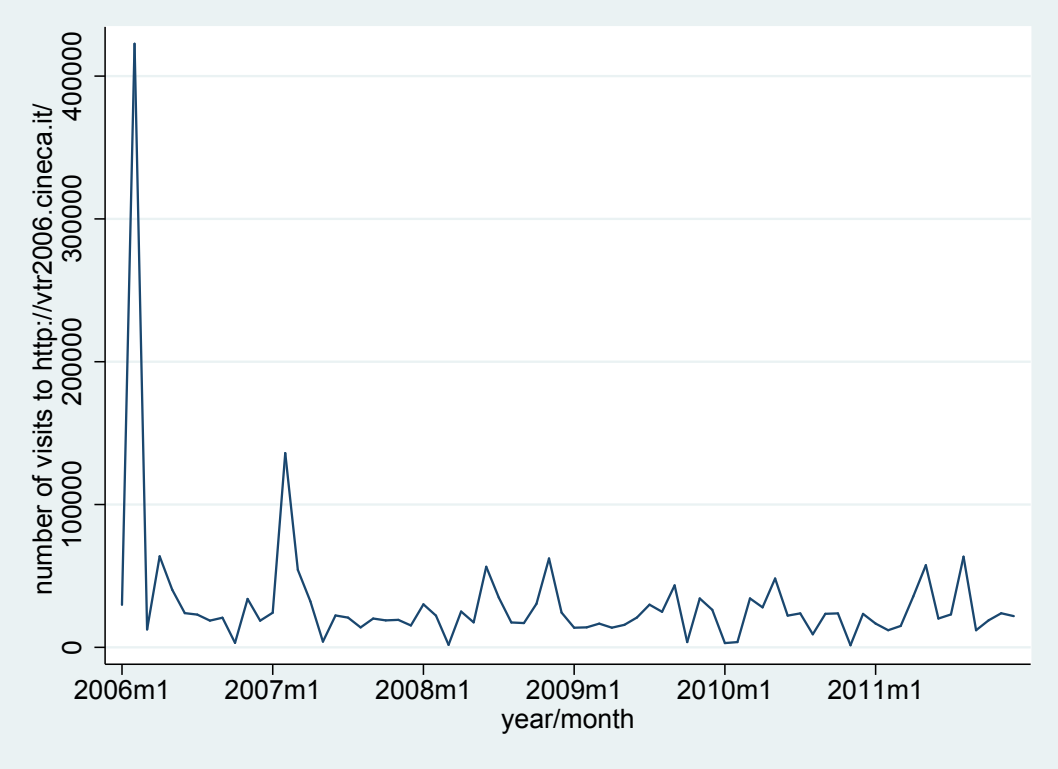
Note. Results of the search in the historical archive of the Italian newspaper *La Repubblica* for the phrase "Comitato di Indirizzo per la Valutazione della Ricerca" (Steering Committee for Research Evaluation, CIVR), which is the committee that was in charge of managing the VTR, and which published the results of the VTR in the website http://vtr2006.cineca.it/. We limited the search to 2006, i.e. the year when the VTR's final results were released, and show in the table only the results related to the VTR.

Figure D1: Trend in internet searches for the abbreviation "CIVR"



Note. Trend in internet searches for the "CIVR", i.e. the abbreviation for the Italian term Steering Committee for Research Evaluation (*Comitato di Indirizzo per la Valutazione della Ricerca*). The maximum number is normalised to 100.

Figure D2: Number of visits to the website that published the VTR results



Note. Since the website that published the results (http://vtr2006.cineca.it/) is offline since 2015, the access statistics were retrieved from the backup of the website provided by *Internet Archive: Wayback Machine* running the search query: https://web.archive.org/web/20120701000000*/http://vtr2006.cineca.it/.

E Probability of using the internet or the press to collect information about universities

Table E1: Sample descriptive statistics

Variables	N. obs.	Mean	Std. Dev.
Dependent variable:			
Used internet or press to collect information	15,702	0.38	
Control variables:			
VTR score	15,702	0.39	0.40
% Excellent products	15,702	15.08	19.82
Female	15,702	0.62	
Age group (ref. 25 or more)			
24	15,702	0.06	
23	15,702	0.44	
less than 23	15,702	0.46	
Father education (ref. no education/primary)			
lower secondary	15,702	0.35	
upper secondary	15,702	0.45	
tertiary	15,702	0.13	
Mother education (ref. no education/primary)			
lower secondary	15,702	0.33	
upper secondary	15,702	0.48	
tertiary	15,702	0.12	
Secondary school track (ref. academic)			
vocational	15,702	0.12	
technical	15,702	0.30	
pedagogical	15,702	0.19	
artistic	15,702	0.07	
Secondary school final exam marks	15,702	80.88	12.41
Years of enrolment in higher education (ref. 2004)			
2005	15,702	0.06	
2006	15,702	0.02	
2007	15,702	0.41	
2008	15,702	0.05	
2009	15,702	0.02	
2010	15,702	0.01	

Note. Sample descriptive statistics refer to the sample selected from the 2007 and 2011 waves of the ISTAT Survey of Secondary School Graduates according to the rules described in Section 6. Standard deviations (Std. Dev.) are not reported for dichotomous variables. Mother's and father's education refer to when the student was 14 years old. Reference categories for categorical variables are reported in brackets. For the sake of space the table does not report the fixed effects for the subject-group, *alma maters*, survey waves and the region of the secondary school.

Table E2: Probability of using the internet or the press to collect information about universities

Variables	(1)	(2)	(3)
Panel A.			
VTR score · $Post_{2005}$	0.012*	0.005	0.004
	(0.007)	(0.007)	(0.008)
Number of observations	15702	15701	15673
Panel B.			
VTR score · $Post_{2005}$	0.008	0.002	0.006
	(0.008)	(0.008)	(0.010)
VTR score · $Post_{2005}$ · Q4	0.013	0.009	-0.004
	(0.019)	(0.017)	(0.022)
Number of observations	15702	15701	15673
Fixed effects (all panels)			
Subject-group	Yes	Yes	No
HEI	No	Yes	No
Subject-group-HEI	No	No	Yes
Region of school	Yes	Yes	Yes
Survey year	Yes	Yes	Yes
Year of enrolment	Yes	Yes	Yes

*, ** statistically significant at the 10 and 5% levels. Standard errors are clustered at the subject-group-HEI level.

Note. The dependent variable is a dichotomous indicator for using the internet or the press as the main sources of information on universities, for the students who enrolled in first-level degrees. The model is estimated with OLS (i.e. linear probability model). Q4 is a dichotomous indicator for the fourth quartile of the VTR score. The individual level data come from the 2007 and 2011 waves of the ISTAT Survey of Secondary School Graduates. All regressions also include controls for: student age group at the time of the survey (25 or more, 24, 23, less than 23), gender, father education, mother education, secondary school track (vocational, technical, academic, pedagogical, artistic) and the secondary school final exam marks. The number of observations differs across columns because singletons (defined by the combination of fixed effects) are dropped from the estimation.

F Models controlling for Censis-Repubblica university ranking

Table F1: Effect of VTR on (log) enrolment of students including Censis-Repubblica score

Variables	(1)	(2)	(3)	(4)	(5)	(6)
		VTR score			% Excellent products	
Panel A. Total enrolment						
Censis-Repubblica score	0.060**	0.059**	0.012	0.059**	0.058**	0.010
	(0.025)	(0.028)	(0.023)	(0.025)	(0.028)	(0.023)
VTR · $Post_{2005}$	0.033*	0.023	0.014	0.056**	0.062**	0.060**
	(0.020)	(0.024)	(0.024)	(0.022)	(0.030)	(0.023)
Number of observations	7350	7302	7302	7350	7302	7302
R^2	0.824	0.841	0.886	0.824	0.842	0.887
Panel B. High-mark enrolment						
Censis-Repubblica score	0.064*	0.060	0.023	0.062*	0.060	0.019
	(0.035)	(0.039)	(0.033)	(0.034)	(0.038)	(0.033)
VTR · $Post_{2005}$	0.059**	0.064**	-0.005	0.085***	0.102***	0.085**
	(0.026)	(0.031)	(0.042)	(0.028)	(0.031)	(0.036)
Number of observations	7302	7254	7254	7302	7254	7254
R^2	0.747	0.780	0.835	0.747	0.780	0.835
Panel C. Academic-track enrolment						
Censis-Repubblica score	0.054	0.081**	0.031	0.049	0.080**	0.028
	(0.037)	(0.036)	(0.033)	(0.037)	(0.036)	(0.033)
VTR · $Post_{2005}$	0.000	0.011	0.028	0.041	0.074**	0.124***
	(0.028)	(0.033)	(0.040)	(0.033)	(0.034)	(0.038)
Number of observations	7302	7254	7254	7302	7254	7254
R^2	0.729	0.802	0.855	0.729	0.803	0.855
control variables (all panels):						
Subject-group-HEI FE	Yes	Yes	Yes	Yes	Yes	Yes
Province and year FE	Yes	No	No	Yes	No	No
Province-year FE	No	Yes	Yes	No	Yes	Yes
Subject-group-HEI linear time trends	No	No	Yes	No	No	Yes

*, **, *** statistically significant at the 10, 5 and 1% levels. Standard errors are clustered at the subject-group-HEI level.

Note. Panel A, B and C refer to models using as dependent variables the logarithm of total enrolments, of high-mark enrolments and of academic-track enrolments, respectively. In columns 1-3 the VTR variable listed in the first column ("Variables") is the VTR score and in columns 4-6 is the % of excellent research products. The number of observations differs across panels because some HEIs did not provide data on the number of student enrolments by secondary school final mark and secondary school track. Moreover, the number of observations differs across columns because singleton groups (defined by the combination of fixed effects) are dropped in the estimation.